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built-in potential equals the difference in work function of the two adjacent p-n diodes in thermal equilibrium. Bulk contact of a MOSFET also referred to as the substrate contact. -C- ABCDEFGHIJKLMNOPQRSTUVWXYZ Capacitance Charge per unit voltage Channel Channel implantation Ion implantation in the channel region used to adjust the threshold voltage of a MOSFET. bart/book/book/append/glossary.htm (1 of 8)11/10/2004 17:24:41 Appendix 5 Channel length modulation Variation of the channel due to an increase of the depletion region when increasing the drain voltage. A reduction of the channel yields a higher current. CMOS Complementary metal oxide silicon (transistor) Compensation The process of adding donors and acceptor to a crystal Conduction band Lowest empty or partially filled band in a semiconductor Conductivity The ratio of the current density to the applied electric field Continuity equation Crystal Equation which states that the rate of change of a density of particles equals the net flux of particles coming in A solid which consists of atoms placed in a periodic arrangement Crystalline Made of one or multiple crystals C-V measurement Capacitance versus voltage measurement -D- ABCDEFGHIJKLMNOPQRSTUVWXYZ de Broglie wavelength Wavelength of a particle  $\lambda = h/p$  Debye length Density of states Depletion Depletion layer width Depletion mode FET Characteristic length over which the carrier density in a semiconductor changes by a factor e The density of electronic states per unit energy and per unit volume Removal of free carriers in a semiconductor Width of the region close to the p-n junction without free carriers Transistor, which is normally on if the gate is connected to the source Depletion region of a p-n diode Region close to the p-n junction without free carriers DIBL Drain induced barrier lowering Diffusion Motion of particles caused by thermal energy Diffusion length Donor Drain Average distance minority carriers travel in a quasi-neutral region before they recombine An atom which is likely to give off one or more electrons when placed in a crystal Contact region of a MOSFET to which the electrons in the channel flow DRAM Dynamic random access memory Drift Motion of carriers caused by an electric field -E- ABCDEFGHIJKLMNOPQRSTUVWXYZ EAPROM Electrically alterable programmable read only memory Edge effects EEPROM Erasable electrically programmable read only memory bart/book/book/append/glossary.htm (2 of 8)11/10/2004 17:24:41 Appendix 5 Electron Particle with spin 1/2 and carrying a single negative charge (1.6 x 10<sup>-19</sup> Coulomb) Energy band A collection of closely spaced energy levels Energy level The energy which an electron can have Enhancement FET Transistor, which is normally off if the gate is connected to the source. Entropy Heat divided by absolute temperature Epitaxial layer Thin layer of a single crystalline semiconductor grown on a substrate EPROM Electrically programmable read only memory -F- ABCDEFGHIJKLMNOPQRSTUVWXYZ FAMOS Fermi energy Floating gate Avalanche injection Metal Oxide Silicon (transistor) The average energy per particle when adding particles to a distribution but without changing the entropy or the volume. Chemists refer to this quantity as being the electrochemical potential Fermions Particles with half-integer spin FET Field Effect Transistor Field implant Doped region under the thick field oxide, which is obtained by ion implantation with the intend to eliminate the effect of the parasitic field oxide transistor. Flash memory Flat band Flatband diagram Flatband diagram Flatband diagram Bias conditions of an MOS capacitor for which the energy band diagram of the silicon is flat. The corresponding voltage is called the Flat band voltage Energy band diagram of a M-S junction containing no net charge Energy band diagram of a p-n diode containing no net charge Energy band diagram of a MOS capacitor containing no net charge in the semiconductor Forward bias High current bias mode of a rectifying contact Full-depletion approximation A common approximation which simplifies the electrostatic analysis of semiconductor devices. Assumed is that the depletion region(s) is(are) fully depleted, with abrupt transitions to the adjacent quasi-neutral regions -G- ABCDEFGHIJKLMNOPQRSTUVWXYZ Gate Electrode of an FET, which controls the charge in the channel bart/book/book/append/glossary.htm (3 of 8)11/10/2004 17:24:41 Appendix 5 Gauss' law One of Maxwell's equations, stating that the gradient of the electric field equals the charge density, divided by the dielectric constant. Generation Process by which electron-hole pairs are generated -H- ABCDEFGHIJKLMNOPQRSTUVWXYZ Heat Thermal energy High Injection Hole High injection occurs by definition when, while forward biasing a p-n diode, the minority carrier density equals or exceeds the doping concentration in the semiconductor. See also High-Current Analysis. Particle associated with an empty electron level in an almost filled band Hydrogen atom An atom consisting of a proton and an electron -I- ABCDEFGHIJKLMNOPQRSTUVWXYZ Ideal diode analysis p-n diode analysis based on recombination currents in the quasi-neutral regions Ideal ohmic contact Metal-semiconductor contact with zero resistance Ideality factor A number which characterizes the slope of a current-voltage plot as measured on a semi-logarithmic scale. A slope of a factor e per thermal voltage (or 1 decade/59 mV at room temperature) is considered ideal and is assigned an ideality factor of 1. A lower slope corresponds to a higher ideality factor. Ideality factor Impurity A foreign atom in a crystal Interface Boundary between two materials Intrinsic carrier density The density of electrons and holes in an intrinsic semiconductor Intrinsic semiconductor A semiconductor free of defects or impurities Inversion Inversion layer Ionization I-V characteristics Change of carrier type in a semiconductor obtained by applying an external voltage. In a MOSFET, inversion creates the free carriers, which cause the drain current. The layer of free carriers of opposite type at the semiconductor-oxide interface of a MOSFET The process of adding or removing an electron to/from an atom thereby creating a charged atom (i.e. ion) Current-Voltage characteristics I-V characteristics I-V measurement Current versus voltage measurement -J- ABCDEFGHIJKLMNOPQRSTUVWXYZ bart/book/book/append/glossary.htm (4 of 8)11/10/2004 17:24:41 Appendix 5 -K- ABCDEFGHIJKLMNOPQRSTUVWXYZ -L- ABCDEFGHIJKLMNOPQRSTUVWXYZ Laser diode Latchup p-n diode with an optical cavity, which emits coherent light when forward biased High current state of a CMOS circuit caused by the parasitic bipolar transistors LDD structure Low doped drain transistor structure Light emitting diode (LED) p-n diode which emits light when forward biased LOCOS Local oxidation used to isolate two adjacent devices. Long diode p-n diode with a long quasi-neutral region as compared to the minority carrier diffusion length in that region -M- ABCDEFGHIJKLMNOPQRSTUVWXYZ Majority Carrier Density Mass action law Minority Carrier Density The larger density of the two carrier types (electrons and holes). The majority carrier density is frequently - but not always - equal to the doping density. The law which describes the relation between the densities of species involved in a chemical reaction The lower density of the two carrier types (electrons and holes). The minority carrier density is typically orders of magnitude lower than the majority carrier density, yet plays an important role in p-n diodes and bipolar transistors. Mobility The ratio of the carrier velocity to the applied electric field momentum Mass times velocity MOSFET Metal-Oxide-Semiconductor Field Effect Transistor. See also MOSFET -N- ABCDEFGHIJKLMNOPQRSTUVWXYZ n+ semiconductor n-type semiconductor with high donor density (< 1018 cm<sup>3</sup>) n- semiconductor n-type semiconductor with low donor density (< 1016 cm<sup>-3</sup>) -O- ABCDEFGHIJKLMNOPQRSTUVWXYZ Ohmic contact One-sided p-n junction Output conductance Overlap capacitance Metal-semiconductor contact with a linear current-voltage characteristic and low resistance Junction with a very large doping density on one side and a very low density of the other side. Ratio of output current variation to the output voltage variation Capacitance between the gate and the source/drain due to the overlap between the gate and the source/drain regions. bart/book/book/append/glossary.htm (5 of 8)11/10/2004 17:24:41 Appendix 5 -P- ABCDEFGHIJKLMNOPQRSTUVWXYZ p+ semiconductor p-type semiconductor with high donor density (< 1018 cm<sup>-3</sup>) p- semiconductor p-type semiconductor with low donor density (< 1016 cm<sup>-3</sup>) Particle-wave duality Photodiode Photoelectric effect Quantum mechanical concept, which states that particles can behave as waves and waves can behave as particles A p-n junction which can be exposed to light, thereby yielding a photocurrent Emission of electrons from a metal when applying light with photon energy larger than the workfunction of the metal Photon Quantum of electromagnetic radiation p-n junction A junction between an n-type and a p-type semiconductor Poisson's equation Second order differential equation which relates the potential,  $\phi$ , to the charge density,  $\rho$ . Poisson's equation Poly-silicon Poly-crystalline silicon. Sometimes referred to as poly. PROM Programmable read only memory Punch through Breakdown mechanism caused by the overlap between the source and drain depletion regions -Q- ABCDEFGHIJKLMNOPQRSTUVWXYZ Quantum mechanics Theory which describes particles by a wavefunction Quasi-neutral region Doped semiconductor region containing free carriers and being almost neutral Quasi-neutral region -R- ABCDEFGHIJKLMNOPQRSTUVWXYZ RAM Random access memory Recombination Process by which electron-hole pairs are removed Current due to recombination of carriers in the depletion region of a p-n diode Current due to band-to-band recombination of carriers in Recombination-generation current in a p-n diode the depletion region of a p-n diode Recombination-generation current in a p-n diode Current due to Shockley-Hall-Read recombination of carriers in the depletion region of a p-n diode Rectifier Device which converts an AC signal into a DC signal. Resistivity The ratio of the applied voltage to the current Reverse bias Low current bias mode of a rectifying contact Reverse bias bart/book/book/append/glossary.htm (6 of 8)11/10/2004 17:24:41 Appendix 5 Richardson constant Richardson velocity Material constant which affects the thermionic emission current in a metal-semiconductor junction Average thermal velocity of carriers moving in a specific direction ROM Read only memory Rydberg Unit of atomic energy = 13.6 eV -S- ABCDEFGHIJKLMNOPQRSTUVWXYZ Saturation Velocity Schottky barrier Schottky barrier diode Schottky barrier lowering Maximum velocity which can be obtained in a specific semiconductor Barrier between a metal and semiconductor as seen by an electron or hole at the Fermi energy in the metal Metal-semiconductor junction with a depletion region under the metal Lowering of the Schottky barrier height due to image forces (only used in current calculations) Series resistance Shell Short channel effects Short diode Solar cell Source State Strong Inversion Substrate Atomic states which are associated with one principle quantum number Deviations from the one-dimensional transistor model as observed in short channel transistors p-n diode with a short quasi-neutral region as compared to the minority carrier diffusion length in that region A p-n diode, which converts optical power into electrical power Contact region of a MOSFET from which the electrons in the channel originate A single solution to Schrödinger's equation defined by a unique set of quantum numbers Strong inversion is obtained when the carrier density in an inversion layer equals or exceeds the carrier density in the substrate. The material in which a device is embedded or on to of which a device is fabricated Subthreshold current Transistor current when biased below threshold Surface state Midgap state caused by the termination of the lattice at the surface of a semiconductor -T- ABCDEFGHIJKLMNOPQRSTUVWXYZ Thermal energy Energy associated with the temperature of an object Thermal equilibrium Threshold Voltage A system is in thermal equilibrium if every ongoing process is exactly balanced by its inverse. The gate-source voltage at which a transistor starts to conduct. bart/book/book/append/glossary.htm (7 of 8)11/10/2004 17:24:41 Appendix 5 Transconductance Transfer characteristic Transistor Tunnel contact Tunneling Ratio of output current variation to the input voltage variation Output voltage of a device plotted as a function of the input voltage Contraction of transresistance, a term used to describe a resistance which is controlled by a voltage at another node. Ohmic contact in which carriers tunnel through a thin barrier layer Quantum mechanical process by which a particle can pass through a barrier rather than having to go over the barrier -U- ABCDEFGHIJKLMNOPQRSTUVWXYZ -V- ABCDEFGHIJKLMNOPQRSTUVWXYZ Valence band Highest filled or almost filled band in a semiconductor Valence electrons Electrons in the outer shell of an atom Variable Depletion Layer Model A MOSFET model which includes the variable depletion layer width between the inversion layer and the substrate -W- ABCDEFGHIJKLMNOPQRSTUVWXYZ Wave number Number of zero crossings per unit length times  $\pi$  Wave packet Wave description of a localized particle Well Doped region of opposite doping type used in a CMOS process Work Mechanical energy Work function Potential an electron at the Fermi energy needs to gain to escape from a solid -X- ABCDEFGHIJKLMNOPQRSTUVWXYZ -Y- ABCDEFGHIJKLMNOPQRSTUVWXYZ -Z- ABCDEFGHIJKLMNOPQRSTUVWXYZ Zener breakdown Breakdown mechanism caused by tunneling of carriers through the energy bandgap bart/book/book/append/glossary.htm (8 of 8)11/10/2004 17:24:41 Appendix 2 Title Page Table of Contents Help Copyright B. Van Zeghbroeck, 2004 Appendix: Quick Access Title Page Table of Contents CDROM Help Introduction 1 2 3 4 Chapter 1: 1.1, 1.2, 1.3, 1.4, 1.ex 1.p 1.r 1.b 1.eq Chapter 2: 2.1, 2.2, 2.3, 2.4, 2.5, 2.6, 2.7, 2.8, 2.9, 2.10, 2.11, 2.ex 2.p 2.r 2.b 2.eq Chapter 3: 3.1, 3.2, 3.3, 3.4, 3.5, 3.6, 3.7, 3.8, 3.9, 3.ex 3.p 3.r 3.b 3.eq Chapter 4: 4.1, 4.2, 4.3, 4.4, 4.5, 4.6, 4.7, 4.8, 4.9, 4.10, 4.ex 4.p 4.r 4.b 4.eq Chapter 5: 5.1, 5.2, 5.3, 5.4, 5.5, 5.6, 5.7, 5.8, 5.9, 5.ex 5.p 5.r 5.b 5.eq Chapter 6: 6.1, 6.2, 6.3, 6.4, 6.5, 6.6, 6.7, 6.ex 6.p 6.r 6.b 6.eq Chapter 7: 7.1, 7.2, 7.3, 7.4, 7.5, 7.6, 7.7, 7.8, 7.9, 7.ex 7.p 7.r 7.b 7.eq Appendix: A.1 A.2 A.3 A.4 A.5 A.6 A.7 A.8 A.9 A.10 A.11 A.12 A.13 A.14 A.15 A.16 Glossary bart/book/book/append/quick.html 11/10/2004 17:24:53



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